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Targeting the Mesolithic: Interdisciplinary approaches to archaeological prospection in the Brown Bank area, southern North Sea

Tine Missiaen[a,**], Simon Fitch[b,*], Rachel Harding[b], Merle Muru[b,c], Andy Fraser[b], Maikel De Clercq[d,1], David Garcia Moreno[d,2], Wim Versteeg[a], Freek S. Busschers[e], Sytze van Heteren[e], Marc P. Hijma[f], Gert-Jan Reichart[g,h], Vince Gaffney[b]

[a] Flanders Marine Institute (VLIZ), InnovOcean Site, Wandelaarkaai 7, B-8400, Ostend, Belgium
[b] School of Archaeological and Forensic Sciences, University of Bradford, Bradford, BD7 1DP, UK
[c] Department of Geography, Institute of Ecology and Earth Sciences, University of Tartu, Vanemuise 46, Tartu, Estonia
[d] Department of Geology, Ghent University, Krijgslaan 281 S8, B-9000, Ghent, Belgium
[e] TNO - Geological Survey of the Netherlands, Princetonlaan 6, 3508 TA, Utrecht, the Netherlands
[f] Deltares Research Institute, Department of Applied Geology and Geophysics, Utrecht, the Netherlands
[g] Department of Earth Sciences, Utrecht University, Princetonlaan 8A, 3584 CB, Utrecht, the Netherlands
[h] Department of Ocean Systems, Royal Netherlands Institute for Sea Research (NIOZ), 1790 AB Den Burg, Texel, and Utrecht University, the Netherlands

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A B S T R A C T

This paper describes some results of the research undertaken over the Brown Bank area during recent (2018/2019) geoarchaeological surveys in the North Sea which included seismic imaging, shallow (vibro)coring and dredging. It examines the benefits of simultaneous high-resolution (0.5 – 1 m) and ultra-high-resolution (10–20 cm) seismic survey techniques and a staged approach to resolving the submerged Holocene landscape in the highest possible detail for the purpose of targeted prospecting for archaeological material from the Mesolithic landscape of Doggerland. The materials recovered from such surveys offer significantly greater information due to an enhanced understanding of the context in which they were recovered. The importance of this information cannot be understated archaeologically, as few locations on land provide the opportunity to recover archaeological finds in situ within preserved landscapes. Moreover, it allows offshore areas of potential human activity to be prospected with some certainty of success.

1. Introduction

The Brown Bank has long been known to archaeologists as an area rich in material relating to the Mesolithic occupation of Doggerland. The regular recovery of both faunal remains, artefactual evidence, in the form of bone, stone, antler artefacts and human remains found as a result of serendipitous dredged finds and targeted 'fishing expeditions' demonstrate the range of Mesolithic material that can be recovered (Louwe Kooijmans, 1970; Glimmerveen et al., 2004; Verhart, 2004; Mol et al., 2006; Peeters, 2011; van der Plicht et al., 2016; Peeters and Amkreutz, 2020). Despite this apparent bounty, it is worth bearing in mind the nature of these finds, which are often recovered from kilometre long trawls, or as part of sand extraction projects. They are not, in any sense, *in-situ* finds, although the artefacts themselves have scientific value, their analysis including Isotopes (van der Plicht et al., 2016), morphology (Amkreutz and Spithoven, 2019) and C14 dating (Smith and Bonsall, 1991). Consequently, such finds are essentially without archaeological site context and frequently can only possess, at best, coarse locational information.

This fascinating array of archaeological finds is, however, a significant group because they relate to a difficult to access, submerged landscape. Moreover, the preservation of organic materials demonstrated through these finds is frequently excellent. Indeed, conditions for preservation are often so good that finds of Mesolithic human bone from

* Corresponding author.
** Corresponding author.
E-mail addresses: tine.missiaen@vliz.be (T. Missiaen), S.Fitch@bradford.ac.uk (S. Fitch).
[1] Current address: Jan De Nul NV, Tragel 60, B-9308 Aalst, Belgium.
[2] Current address: Geological Survey of Belgium, Jennerstraat 13, B-1000 Brussels, Belgium.

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the Dutch sector exceeds that which is currently reported from the contemporary terrestrial record (Verhart, 2008; Peeters et al., 2019). They therefore provide an insight into underrepresented aspects of the Mesolithic archaeological record and, significantly, can be used to suggest areas with greater research potential. Consequently, there is a real need to locate the origin of this material and study those areas in order to fully understand the Mesolithic record of the region.

The Brown Bank forms a ridge on the seafloor some 85 km off the Dutch coast in the central part of the southern North Sea (Fig. 1). The bank is approximately 25 km long and 2 km wide and sits 22-16m below sea level with a swale between 40 and 42 m deep on the eastern side. The seabed surrounding the bank is between 28 and 32m below sea level. The ridge is formed of Weichselian and Holocene deposits (Cameron et al., 1992). The Holocene deposits, relating to the emergent landscape, the Naaldwijk Formation (Rijsdijk et al., 2005), correspond in date to the Mesolithic period (10,000 to 7500 BP). The Holocene deposits cover a well-preserved Pleistocene palaeosurface, and these therefore are the most likely sources of previously recorded Mesolithic finds.

Notwithstanding the significant number of chance archaeological finds from this area, currently little is known about the prehistoric landscape around Brown Bank. This is a significant contrast to the area around Doggerbank, where mapping of channels and landscape features has been performed (e.g. Gaffney et al., 2009, 2017; Hepp et al., 2017). However, the underlying topography associated with the current ridge, which sits within the generally low-lying Doggerland landscape, would have attracted Mesolithic hunters. This relative high point in the surrounding landscape may have acted as a vantage point to observe game (e.g. Fischer, 2004) and, during the Holocene marine inundation, it would have offered valuable habitable land area as the sea encroached. The geophysical detection of submerged Mesolithic sites has proved relatively difficult in the North Sea area as the signature of Mesolithic activity within geophysical data is poorly understood (Blinkhorn and Powesland, 2018). This situation, therefore, requires researchers to narrow down search areas by targeting locations with greater potential for the preservation of archaeological material.

Given the potential of the archaeological record in the Brown Bank area and the likely benefits to Mesolithic archaeological understanding, a collaborative project was implemented by Flanders Marine Institute (VLIZ), Bradford University's "Europe's Lost Frontiers Project", University of Ghent, TNO - Geological Survey of the Netherlands, Deltares Research Institute, Utrecht University and the Royal Netherlands Institute for Sea Research (NIOZ), to study the area further and, if possible, to locate archaeological material. To date, three expeditions have been undertaken to the Brown Bank during 2018/2019 with further research planned for 2020.

In this paper, we seek to illustrate the first results of the work within the area of the Brown Bank. This includes a case study which exemplifies some of the challenges faced by the project. We discuss the implications that such survey has with respect to prospection for archaeological material, and the impact this may have upon our understanding of subsistence, land use and occupation in the submerged landscapes in the Southern North Sea area.

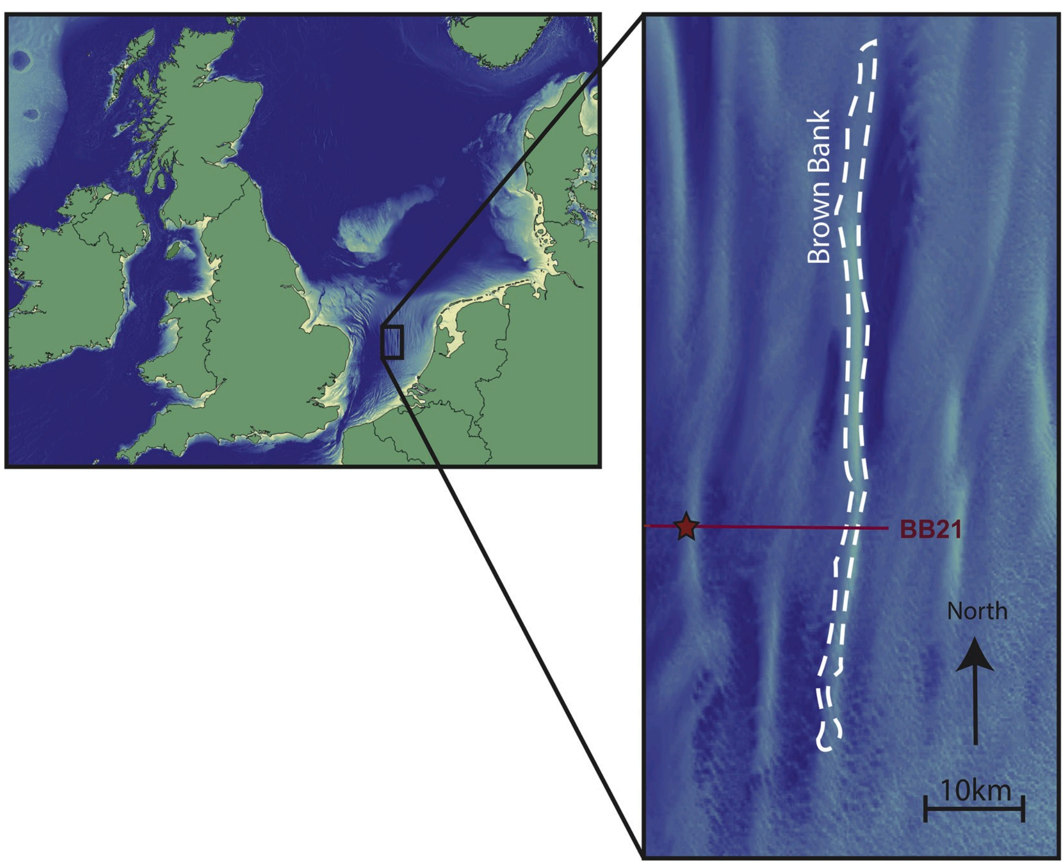

Fig. 1. Location of the area of interest. The location of site VC43 is marked with a red star whilst the position of seismic line BB21 is shown by the red line. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

1.1. Methodology

To prepare for active fieldwork, existing datasets, including bathymetry, finds location and existing geological and seismic data were integrated within a GIS to map the known archaeological materials and identify any patterns within the data. Upon investigation, it became apparent that there were several discrete clusters of material around the Brown Bank. These were suggestive of a potential point of origin within the area. The three marine surveys undertaken in this area were guided using this data.

1.2. 2018 survey

In April 2018, the project team undertook an initial scoping survey using the Belgian Research Vessel RV Belgica. This expedition aimed to assess the area around the Brown Bank geologically, using two different seismic sources. It also sought to provide information on those preserved prehistoric landscapes that had the potential to be sources of mapped archaeological material and that might be subject to detailed study within future sampling campaigns (Fig. 2).

This survey used a multi-tip "Centipede" Sparker source from Ghent University (central frequency 1.1–1.2 kHz) along with a (10-hydrophone) single channel streamer. This system provided information on the subsurface up to a depth of ~80 m with a resolution of 0.5–1 m. Whilst this provided excellent imaging of the deeper layers, the resolution was less than ideal to map the Holocene deposits in detail. Moreover, due to the strong seafloor reflector, the top 2–3 m could not be well resolved. The Sparker system was therefore used in parallel with a Multi-transducer Parametric Echosounder (MPES) source. This was recently acquired by Flanders Marine Institute and arranged in a single beam set-

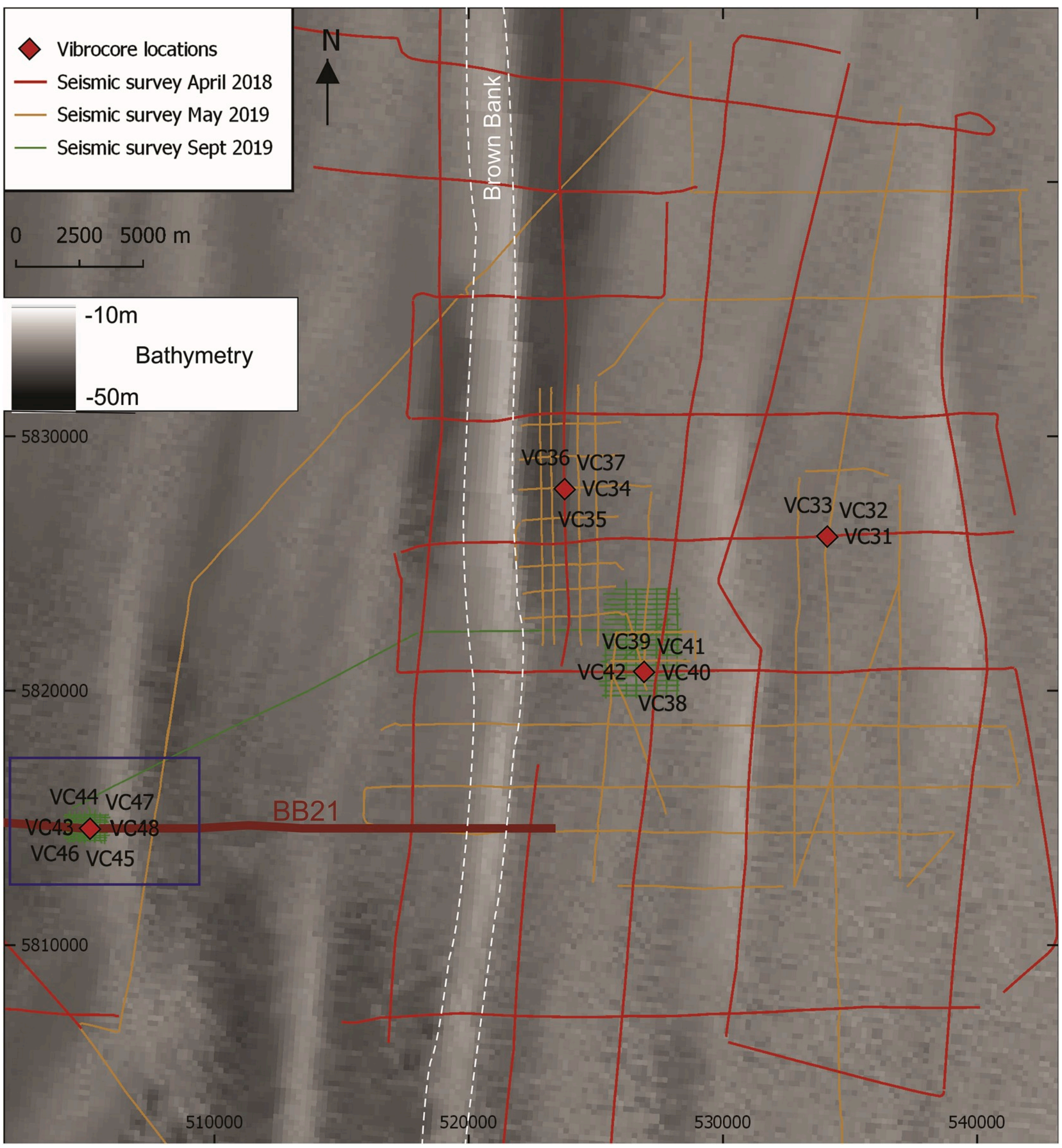

Fig. 2. Map of the seismic surveys and viborocoring undertaken during 2018–2019 by the project team. The blue box indicates the area of interest (site VC43). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

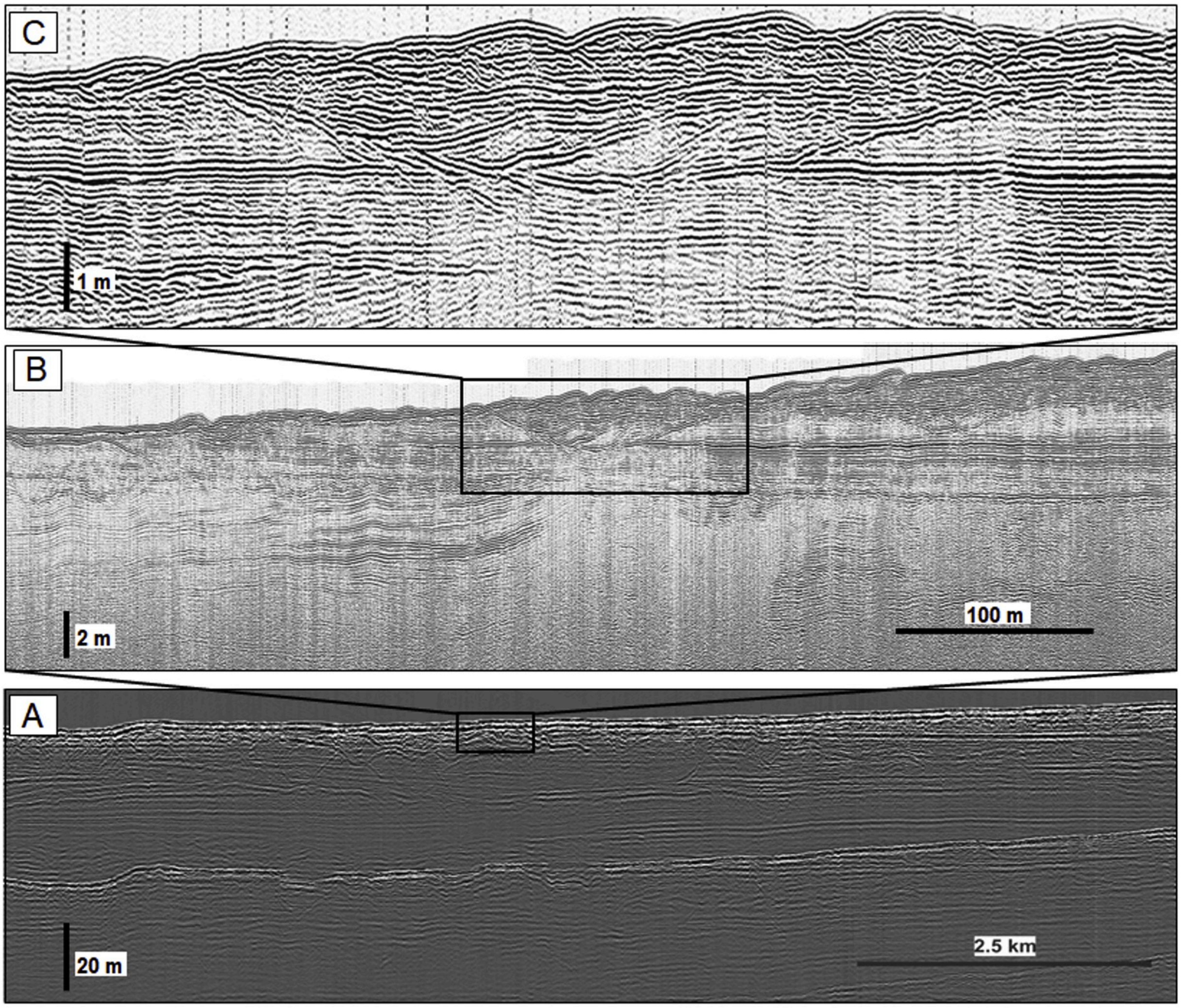

Fig. 3. Source comparison. A - Sparker section from the Brown Bank area; B - Corresponding Multi-transducer Parametric Echosounder (MPES) section from the central part; C – Further zoom-in on the MPES section. It is apparent that the use of both Sparker and MPES datasets allows for a greater understanding of shallow geology. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

up to help increase the energy level. With a frequency of 8–10 kHz, this system provided decimetre level resolution up to 12–15 m below the seafloor and provided excellent imaging of shallow features; many of which were subsequently confirmed as Holocene. High-resolution multibeam (EM3002D) data were also recorded alongside the sub-bottom data. The combination of Sparker and MPES data provided an ideal visualisation of the seafloor and subsurface for prospection purposes (Fig. 3). To allow optimal integration with the Sparker data, the MPES data were converted to SEGY and tidally corrected, with bulk shifts applied using a custom-built program provided by Dr R. Yorston. Tidal and geometric corrections for the Sparker data were performed within the RadExPro software (in addition to other processing such as noise filtering, amplitude correction, swell filtering). Interpretation of the seismic datasets was performed using the IHS Kingdom Suite 2018 software. Unconverted MPES data (SES format) were processed and interpreted using ISE software.

Using the results of this survey, a 4-m vibrocorer was deployed in July 2018 to acquire 18 validation cores over promising targets. The vibrocores were taken at 4 locations, using the NIOZ-operated RV Pelagia (Fig. 2). These cores were used for seismic validation and to provide sediment dating. Radiocarbon dates were acquired from organic material within the cores and additional Optical Stimulated Luminescence dating will be undertaken to supplement these dates.

1.3. 2019 survey

Given the excellent results of the 2018 survey, the group utilised the interpretation generated from the data, in conjunction with the existing GIS, to plan focused surveys during 2019. The first survey, undertaken on RV Belgica in May 2019, utilised broadly the same geophysical instrumentation (multitip Sparker, MPES) to complement the seismic network recorded in 2018. On this occasion, additional seabed sampling gear, including a Hamon Grab and a small dredge (so-called “Gilson Dredge”), were also utilised to support testing of geophysical results and assess whether conditions were favourable for the preservation of archaeological material.

The results allowed the identification of key areas where extremely high-resolution survey could be undertaken in addition to detailed archaeological survey. One of these areas was site VC43, near the Dutch/UK border, where 6 RV Pelagia cores had been recovered in 2018 (for location see Figs. 1 and 2). This site is located on a westward-facing slope and was selected as it provided clear detail of a fluvial channel and associated terrestrial deposits. These deposits also appeared to be accessible by the projects' sampling equipment.

The VC43 site was therefore targeted during a subsequent survey in September 2019 by the Flemish Research Vessel RV Simon Stevin. During this survey the MPES was used in conjunction with multibeam (EM2040), using a line spacing of 100 m E-W and 200 m N–S, and was designed to take advantage of the prevailing seabed conditions. In addition, dredging using a beam trawl was undertaken along a number of targeted transects (6 transects within the area around VC43) and 18 short (1–2.5 m) vibrocores were recovered from 10 locations in the wider Brown Bank area.

2. Results and discussion

2.1. Holocene

Seismic line BB21 acquired in 2018, shown in Fig. 4, provides a west-east seismic section across the area around VC43. This illustrates the significant surface topography of the seabed and (presumably) modern (<4 kya) seafloor features including sand waves. These seafloor features can also be imaged in the bathymetry as N–S-trending peaks and troughs. The modern sediments have an erosional contact with isolated acoustically strong amplitude reflections identified as the top of the Naaldwijk Fm. The bottom of the channel is filled with fluvial sediments, marked by faint shallowly dipping reflections, and covered with modern marine sediments (including several generations of sand waves). The Naaldwijk Fm also has a basal erosional contact with underlying Weichselian deposits. To the east of the section, the base of the Naaldwijk Fm is unclear due to a lack of signal penetration (likely due to the increasing thickness of the overlying sand bank).

Associated with the Naaldwijk Fm is basal peat (Basisveen Bed, Nieuwkoop Fm), represented by a coherent negative, flat parallel reflection, often regarded as indicative of peat layers (e.g. Plets et al., 2007). In this case, we can distinguish two, very closely spaced, negative reflections (Fig. 4 – inset box B). It is thought that these reflectors may represent two thin peat layers separated by a thin sandy layer. The peat deposits also show an erosional contact with the Naaldwijk Fm channel (Fig. 4 - inset box A). Where the core is located directly over the seismic line (VC43), the correspondence between the seismic data and the core is very good. Indeed, in VC43 a clear, thin peat layer can be observed at ~90 cm below the seafloor; the upper part of the peat layer is marked by a thin sandy inclusion (Fig. 6).

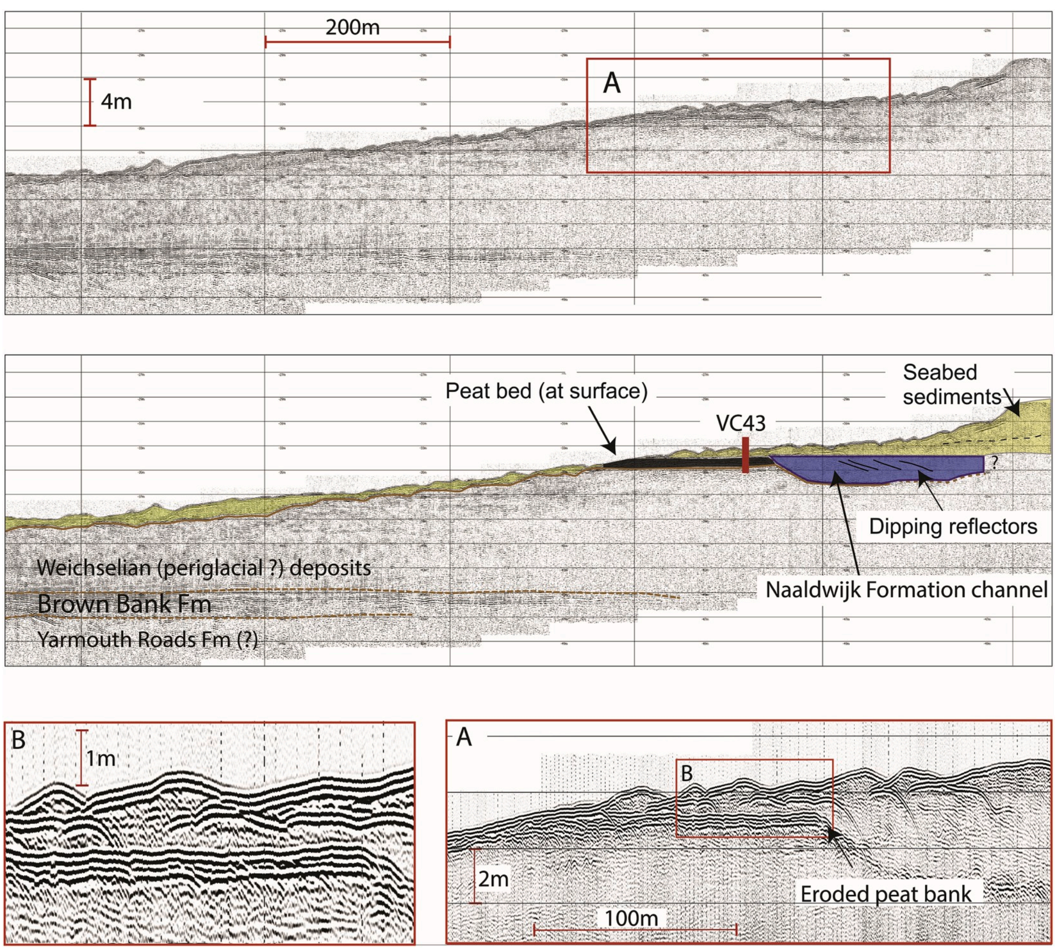

Fig. 4. Part of MPES Line BB21 across the area surrounding VC43. A close-up view of the peat bank is provided in box A, the erosional contact between the channel and the peat bed can be seen clearly.

Other cores were acquired up to a distance of 20 m away from the seismic line (Fig. 5), with some cores (e.g. VC44, VC45) displaying a coherent peat later, whilst other cores (e.g. VC48) displayed only channel fill material (Fig. 6). Given the rapidly changing nature of the shallow features, an additional seismic line was needed to better link the peat bed to the cores, and this was acquired during September 2019 (Fig. 5). Crucially, this line links the peat reflection(s) on the seismic data to peat recovered at ~0.75 m depth in core VC45 (Fig. 6). Subsequent dating of these deposits provided a C14 date of 8972±23 (cal y) BP (SUERC 89491) from the humic acid content of the peat.

Like elsewhere in the Brown Bank region, this peat is thought to have formed on a seasonally flooded, drowning floodplain as early Holocene sea level rose. Meanwhile, salinity and sediment accretion increased (Andrews et al., 2000). An additional core (VC47) was taken in the channel itself (Fig. 5) and this confirmed the erosional nature of the contact between the peat and channel. The core clearly shows an eroded block of peat within the sands of the channel infill material (Fig. 6). Thus, it is possible to suggest that there was a period of activity within the channel that occurs at, or shortly after, 8972 BP ± 23 (cal y) BP.

Additional seismic (MPES) data, acquired in September 2019, spatially extended and validated this interpretation. The extent of the Holocene peat layer could be mapped some 800 m further north with the peat bed being observed to outcrop in the northern part of the mapped area (Fig. 7). The interpreted seismic response suggests that the Holocene channel was oriented North/South with peat banks located on the western and eastern side of the channel (see Fig. 7). The channel with its

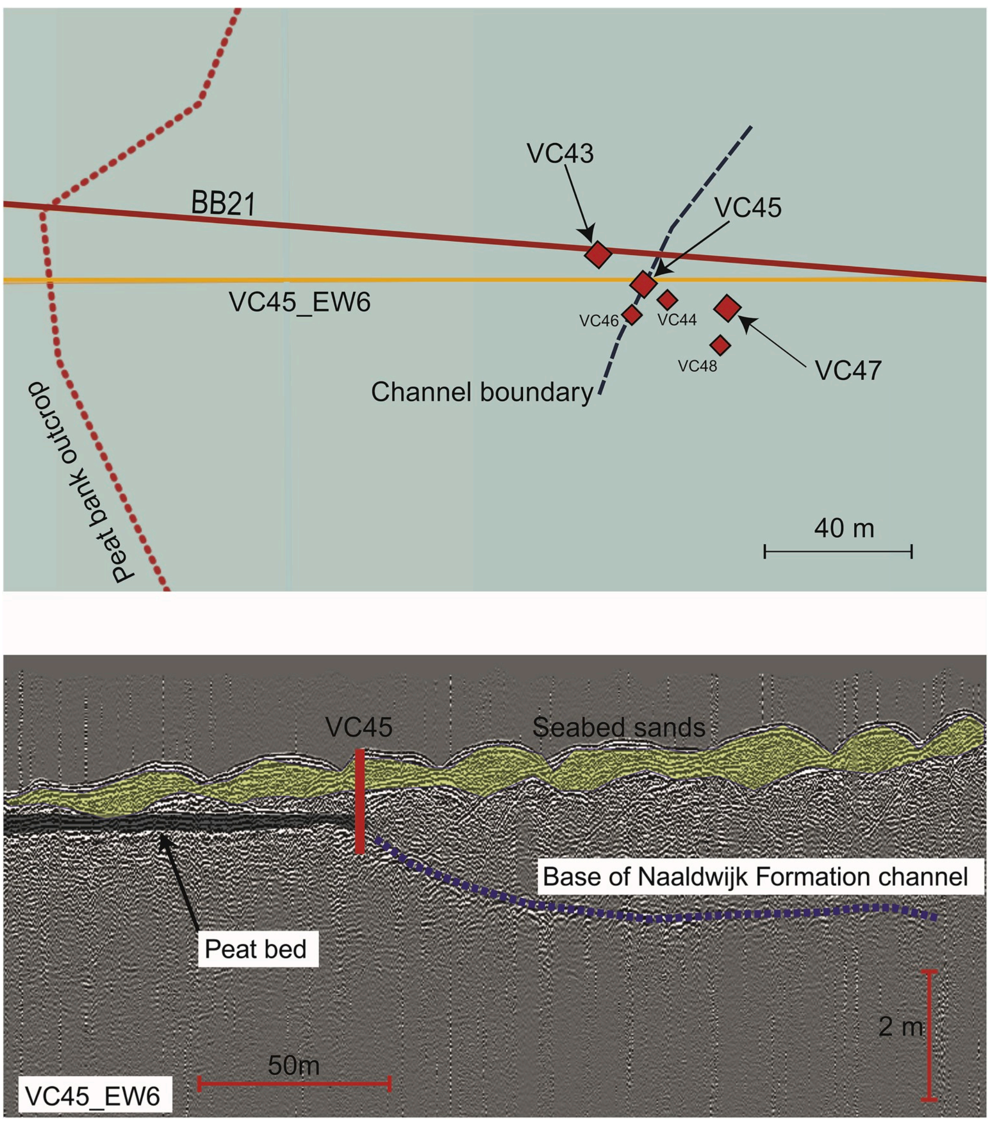

Fig. 5. Top: overview of seismic lines and cores at site VC 43. The red dashed line marks peat outcrop at the seabed. The black dashed line marks the channel boundary. Bottom: Seismic line VC45_EW6 demonstrates that the key peat bed could be linked to material recovered in vibrocore VC45, where a C14 date of 9972±23 BP (SUERC 89491) has been obtained for the peat bed. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

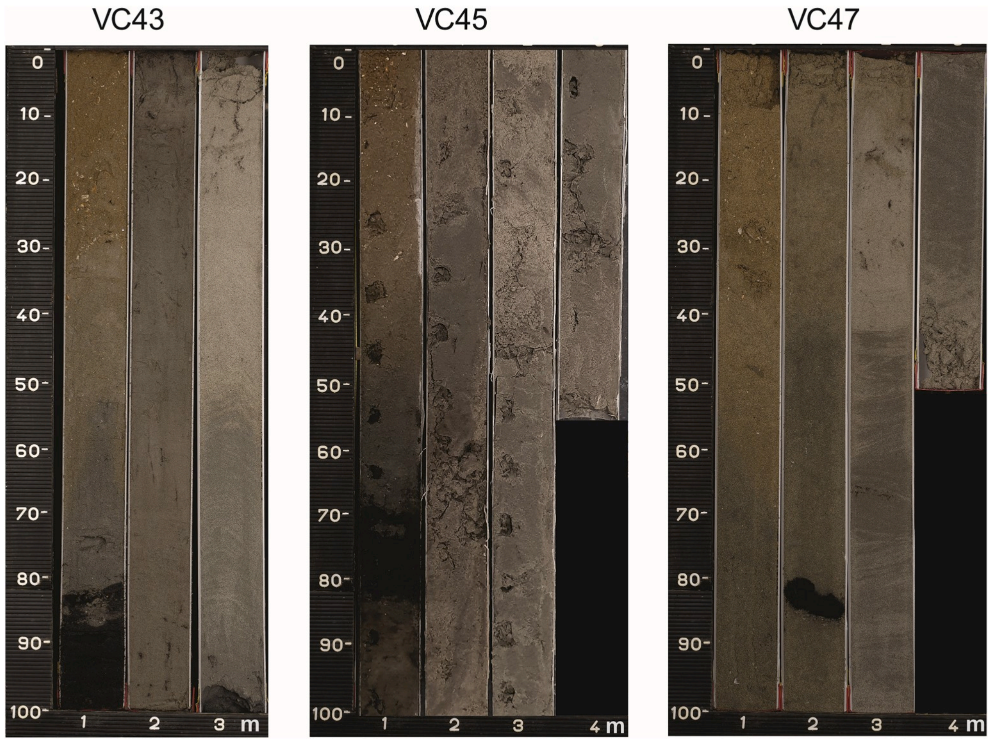

Fig. 6. Cores VC43, VC45 and VC47 (for location see Fig. 5). The Holocene peat bed can be clearly seen in VC43 and VC45, whilst a block of eroded peat can be seen within the sand fill of the Naaldwijk Fm channel in VC47.

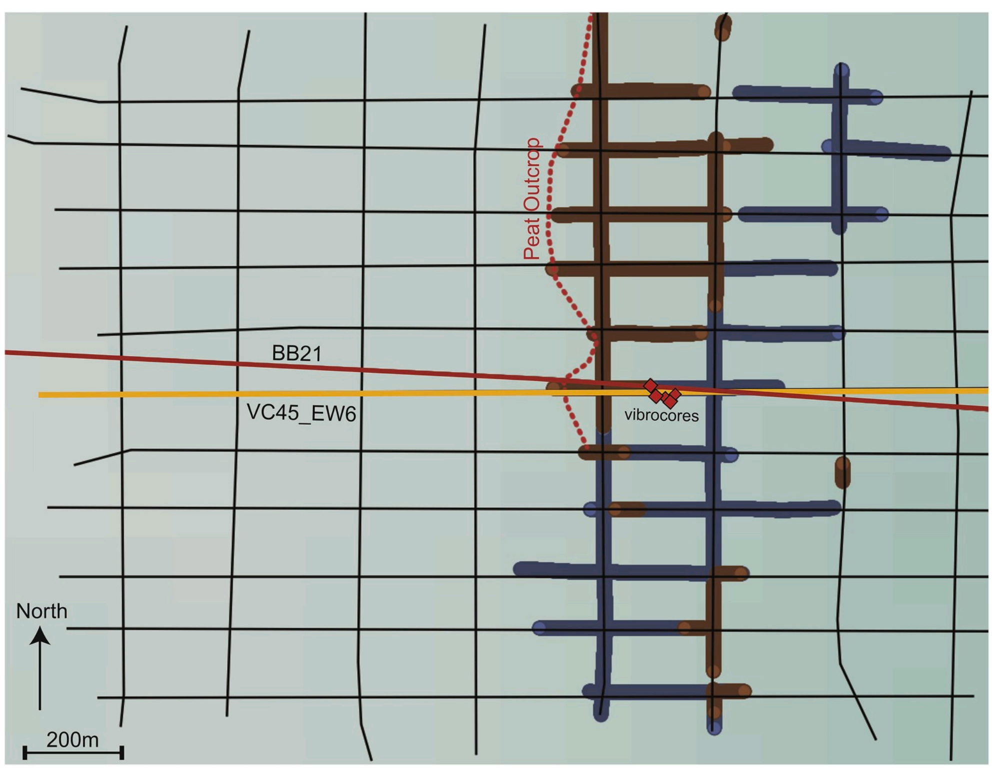

Fig. 7. Dense network of MPES data obtained in the area around VC43. MPES Lines discussed in the text are labelled (red = BB21; yellow = VC45_EW6). Seismic interpretation is also mapped, Brown = interpreted peat reflector, Blue = Naaldwijk Fm channel. The vibrocore locations are represented as red diamonds. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

banks was mapped across an area approx. 1km2 wide.

This interpretation was further validated following short trawls over the area with (supposed) peat outcrops. These recovered a large number of blocks of peat (some with reeds), as well as pieces of wood, charcoal and raw flint (Fig. 8). This material is currently under examination but clearly demonstrates the preservation of organics and plant

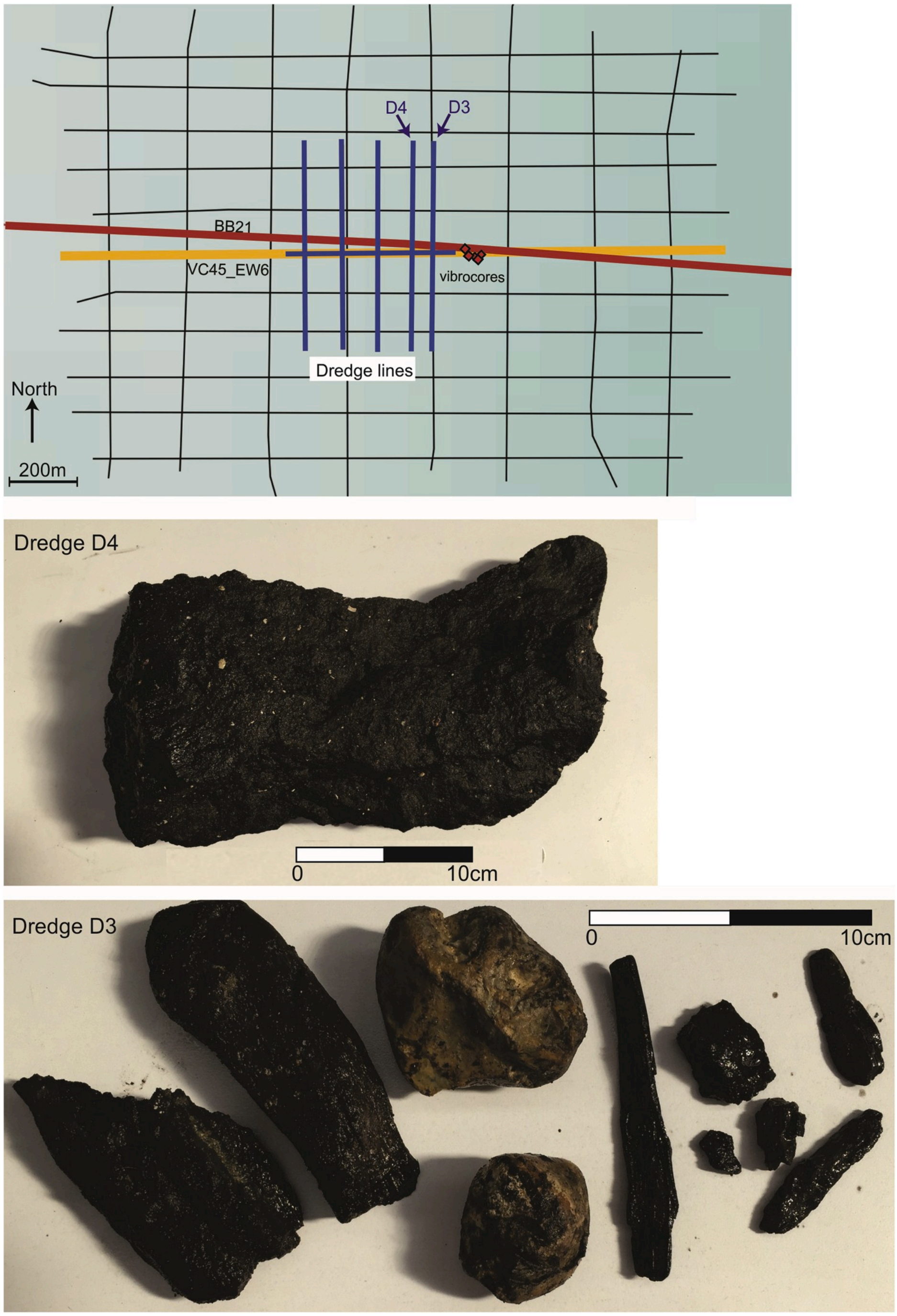

Fig. 8. Location of dredge transects (blue lines) near site VC 43 and examples of the block of peat (Dredge D4) and wood and raw flint finds (Dredge D3). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

macrofossils, and suggests that the potential for preservation of archaeological material in this area is good. Moreover the preserved wood indicates a prehistoric woodland; similar preserved forests are occasionally found around the North Sea coastline and some may be associated with prehistoric settlement.

2.2. The Pleistocene

To the west, downslope, where the Naaldwijk Fm and the peat deposit is absent, the modern sediments have an erosional contact with a largely acoustically weak, transparent and chaotic seismic facies, which is thought to represent sandy deposits (see Fig. 9). These facies were considered by Cameron et al. (1992) to represent the upmost units of the Brown Bank Formation. However, recent work using the seismic data provided by this project (Baten, 2019) ascribed the facies as potentially being deposited between MIS 4 and MIS 1 and possibly representing Weichselian periglacial deposits (Peeters et al., 2015; De Clercq, 2018). Unfortunately, this material has yet to be sampled or dated, and this attribution remains unproven.

Below these transparent seismic facies are a series of locally laterally continuous, laminated, acoustically strong seismic reflections, which is interpreted as part of the early Weichselian Brown Bank Fm (Fig. 9). However, there is variation within this unit, and the upper boundary appears confused and defuse. Additionally, the lower part of the unit

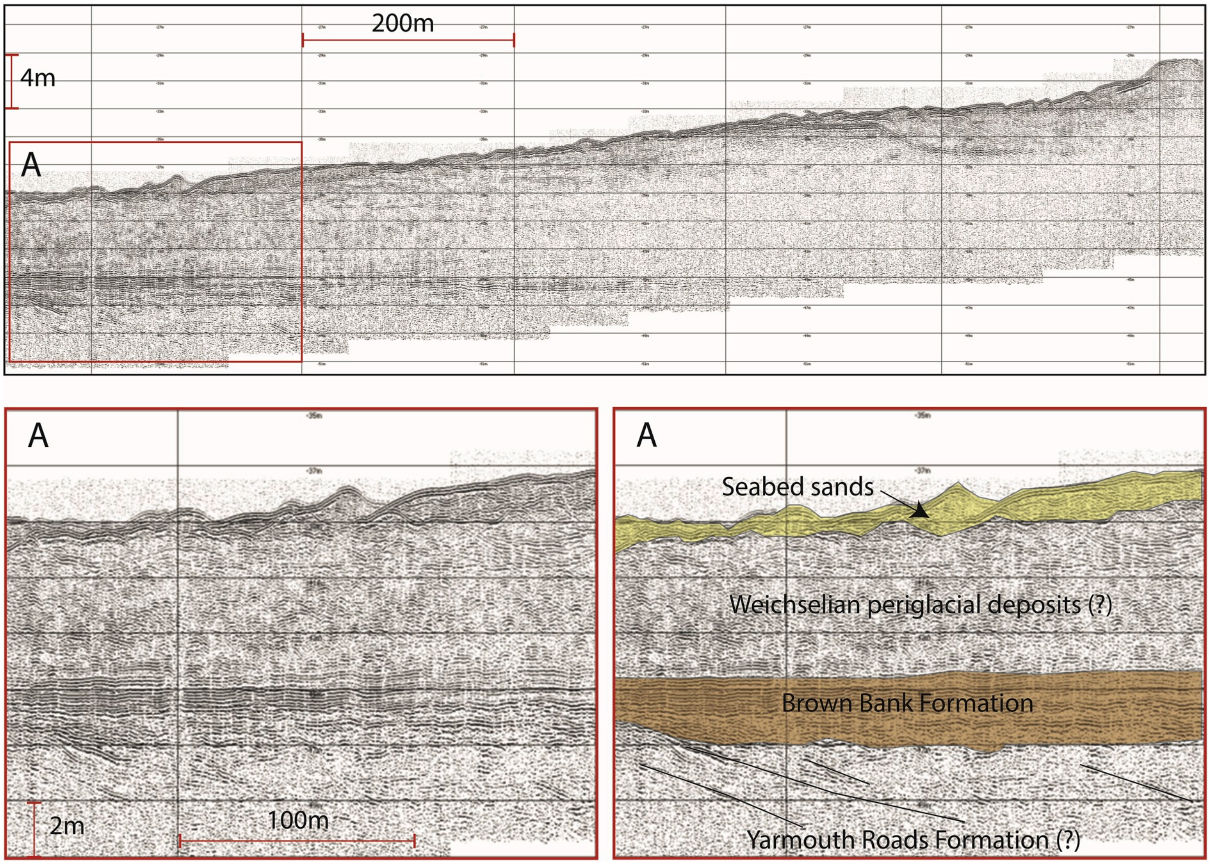

Fig. 9. Part of MPES Line BB21 across the VC43 site. A close-up view of the upper Pleistocene deposits is provided in box A.

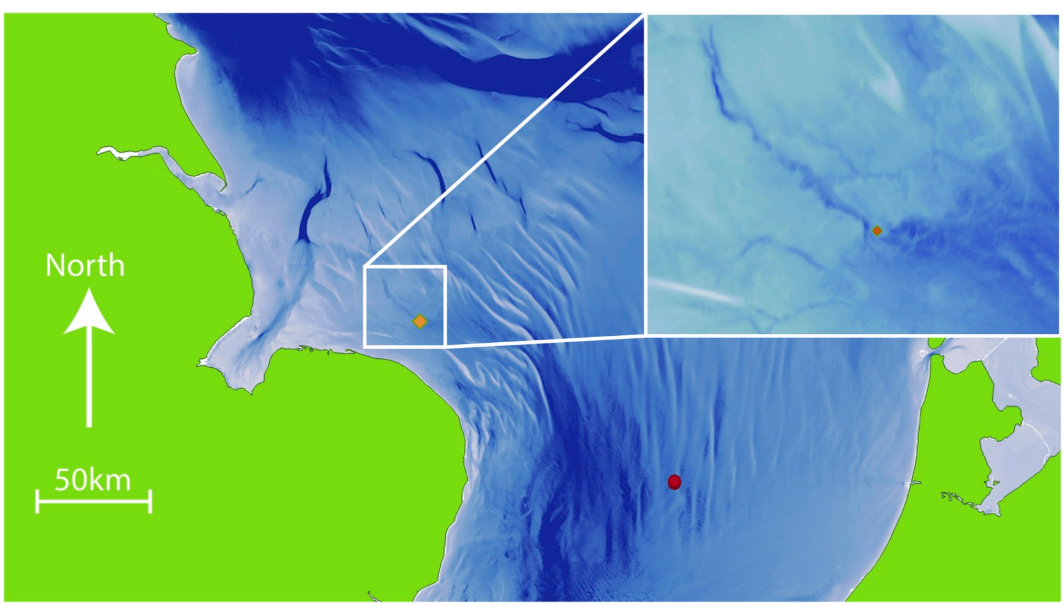

Fig. 10. Location of the Southern River find spot (yellow diamond) with respect to the location of site VC43 (red circle). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

appears less laminated indicating coarser sediment in comparison to the material immediately above (Fig. 9). Given these variations, the attribution as Brown Bank Formation is perhaps too broad a definition. Indeed, Baten (2019) observed several sub-divisions of the Brown Bank Fm, and the unit described here possibly corresponds to a facies believed to represent prodelta or floodplain deposits (Peeters et al., 2015; De Clercq, 2018).

Underlying the laminated seismic unit are a series of shallowly dipping, acoustically weak or transparent reflectors, which may, tentatively, correspond to the Yarmouth Roads Formation (Fig. 9), and are comparable, acoustically, to those deposits identified in this area by Baten (2019). This material is thought to relate to a delta complex which

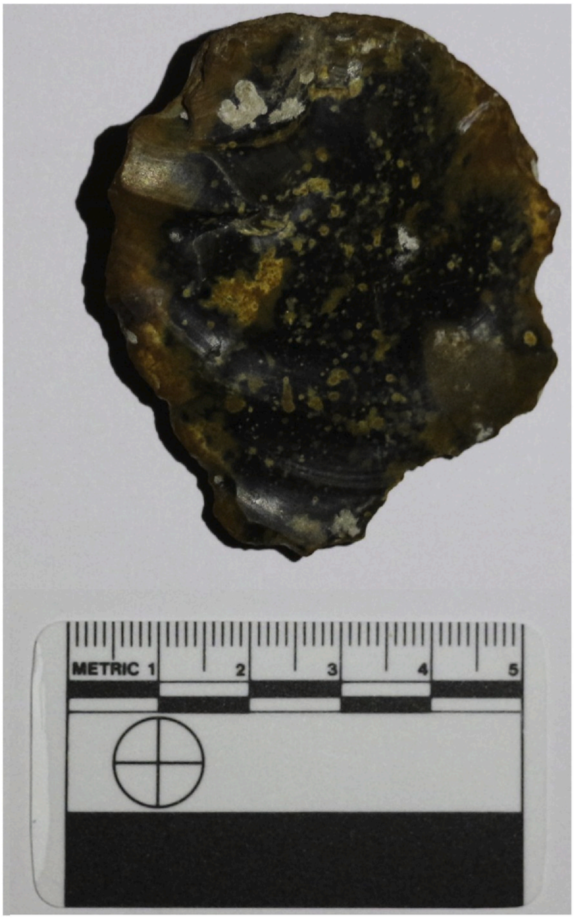

Fig. 11. Hammerstone fragment discovered at the Southern River site (Image courtesy of Micheal Butler, University of Bradford). A 3D scan of this artefact is available online at: https://sketchfab.com/3d-models/777d1c425b5d46df9721a63a915f0c02.

was linked to the Rhine (Gibbard and Lewin, 2016). The complexity of the data seen within the extremely high-resolution MPES dataset demonstrates that this information will assist in refining and improving our interpretation of the region's geology and geomorphology.

2.3. Further implications

Given the success of the methodology demonstrated in this paper, the project team is now seeking to utilise this information to target those areas with the greatest potential for preservation of archaeological materials. For example, the peat deposits identified in and near the VC43 core preserve a range of organic archaeological materials that do not usually survive in dry, terrestrial deposits, including wood and bone (Fig. 8), materials that were used in the Mesolithic to make tools. The riverine environment identified within the seismic data would also have offered a range of plant, animal and flint resources that would have been attractive to contemporary hunter gatherers, and any heightened level of human activity linked to such resources would in turn enhance our chances of detection.

The potential to identify archaeological activity directly is also increased along with the resolution of the exploratory survey. The techniques used as part of this study operate within decimetre ranges and are thus approaching a scale closer to that associated with site prospection on land. Unfortunately, the encountered water depths prohibit ultra-high resolution (cm-range) 3D imaging of the shallow sub-seafloor, as recently performed off the Belgian coast (Missiaen et al., 2018). Detailed seafloor information could however be obtained from high-resolution photographic surveying using an AUV. Should human activity be discovered at site VC43, then the sloping outcrop located on the seabed at VC43 may allow detailed examination by diver excavation (e.g. Momber et al., 2011). However, where conditions do not allow this, then a combination of high-resolution coring and grab sampling, similar to that performed by Sier et al. (2014) may be appropriate. Certainly, the current results provide a degree of optimism that the process of survey undertaken here could be applied elsewhere in the North Sea where similar conditions may be found.

It is pleasing, therefore, that the Brown Bank team has already successfully applied the proposed methodology in a comparable situation and archaeological material has been recovered. In May 2019 dredging carried out in support of a collaborator on the Brown Bank Project, the "Europe's Lost Frontiers" ERC Advanced Grant project, led to the retrieval of several worked flakes from within their study area, off the coast of East Anglia, UK (Fig. 10). These finds were recovered near a channel known as the "Southern River", which was active at roughly the same time as those near site VC43 (ELF051: 8827±30 (cal y) BP SUERC-85715). Whilst material from the dredges is currently under study and will be published fully elsewhere (Gaffney et al., 2019; Gaffney and Fitch, n.d.), the assemblage includes a broken hammerstone (M. Tingle pers. Comm., Fig. 11). This lithic group currently represents the only early archaeological material recovered from the deeper areas of the North Sea through a programme of landscape prospection. Their retrieval suggests that our state of knowledge of the Holocene landscapes of the southern North Sea is rapidly approaching the point that areas of potential human activity may be predicted and prospected with an enhanced likelihood of success.

3. Conclusions

The integrated use of high-resolution and ultra-high-resolution geophysical data offers the potential to study features of archaeological interest in much greater detail. Throughout the project, the methodology has sought to further improve the resolution of shallow geophysical features, especially through the use of dense ultra-high resolution 2D datasets. These have led to improved landscape interpretation and location of previously unknown submerged palaeolandscape features which offer the potential to hold new archives of archaeological data.

The importance of such information cannot be understated archaeologically. Few locations on land provide the opportunity to recover archaeological finds in-situ within well preserved landscapes. The act of submergence has reduced the chance of later erosion and created conditions for the preservation of organic material, which elsewhere may have been eroded and degraded, and thus lost from the archaeological record. Consequently, any materials recovered can be interpreted with confidence and the available environmental data offers a better understanding of the landscape. In contrast to the Mesolithic material that has been recovered by chance from the southern North Sea, new material can now be sourced and located within its associated palaeolandscape, and such material has significantly greater information potential than the chance finds currently associated with the Brown Bank.

Mapping the channel system and peat outcrop has significantly increased the potential for future study in the area, through dredging, coring and remote operated vehicle campaigns. The opportunity to recover and investigate in situ archaeological material, as well as the palaeolandscapes in which they sit, is also enhanced. Given the state of archaeological knowledge of the palaeolandscape in other areas of the North Sea (e.g. Gaffney et al., 2009), it is possible to suggest that this approach could also be used in other areas to focus surveys and to recover archaeological material and improve our knowledge of the paleoenvironmental archive. In doing so Doggerland will change from *terra incognita* to a landscape in which we may, over time, provide a detailed environmental mapping and, eventually, the location of contemporary archaeological settlement.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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